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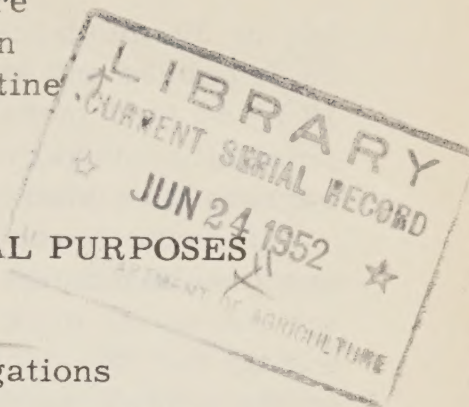


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REARING COCKROACHES FOR EXPERIMENTAL PURPOSES

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Cockroaches are reared at many laboratories for insecticide testing and for use in studies of insect physiology. The literature on methods of rearing cockroaches is scattered. This paper describes methods that have been successful at the Beltsville, Md., laboratories of this Bureau for the rearing of the American cockroach (Periplaneta americana L.) and the German cockroach (Blattella germanica L.). Brief descriptions are also presented on the rearing of the brown-banded cockroach (Supella supellectilium (Serv.)), and the oriental cockroach (Blatta orientalis L.).

American Cockroach

Rearing Room. --The desirability of using rearing rooms of sufficient size was pointed out by Campbell et al. (2). The room used for rearing the American cockroach is 15 by 10 by 9 feet. The temperature of this room is kept between 70° and 80° F. A controlled-temperature cabinet for holding the cultures is built against the wall (fig. 1). It extends from the floor to the ceiling, has three tiers, and is continuous along one length and width of the room. Within the cabinet are five shelves of wooden framing covered with 1/4-inch hardware cloth to allow circulation of air. In one end of the cabinet at the top and bottom are openings covered with 16-mesh wire screening. An exhaust blower is connected to the top opening. Ventilation to the outside of the building is provided by stove piping through which passes 1,350 cubic feet of air a minute when the exhaust blower is operating. The exhaust blower is operated at the convenience of the personnel.

Relative humidity in the cabinet is kept at about 60 percent by a pan of water 24 by 21 by 2 inches, in which are placed nine 4-inch flowerpots to provide additional evaporating surface.

Rearing Cages. --American cockroaches are reared in watertight 26- or 28-gage galvanized-iron cages. One type of cage (fig. 2) is 18 by 14 by 4 inches, with sides folded horizontally 3 inches toward the center and the edges turned up 1/4 inch, so that a copper frame with



16- or 20-mesh bronze or copper screening can be used to confine the cockroaches and keep other insects out. Another type of cage (fig. 3) is 18 by 14 by 7 inches, with straight sides. The cages may be larger or smaller to fit varying needs. Glass jars as well as large drums and barrels have also been used.

Because roaches are generally nocturnal in habit, inverted cartons are provided in the cages for hiding places. The authors use pint-size ice-cream or milk containers, with V-shaped openings cut in the open end so that the cockroaches can enter and rest on the inside as well as on the outside surfaces of the cartons. These cartons also provide additional surface area to accommodate larger numbers of roaches in the cages. A band of vaseline 2 1/2 inches wide is spread around the inside of all cages at the top to prevent the insects from escaping. A complete cage of American roaches is shown in figure 4.

Water is supplied by one of two types of fountains as shown in figure 5. One is a glass tube 1 1/2 inches in diameter and 11 1/2 inches long. It is filled with water, plugged with cotton, and placed in a horizontal position on the floor of the cage. As the roaches drink, the plug recedes down the tube. Small cages require smaller tubes. The other type of fountain is a half-pint jar filled with water and inverted into a shallow dish, with cotton placed so as to provide a moist drinking surface.

Rearing Procedure. --The best way to start a colony of these cockroaches is to obtain a supply of egg capsules from another laboratory culture. Place them in hatching cages (fig. 2) and supply food and water and check once a week, replenishing if necessary. At 2-week intervals collect the unhatched egg capsules by sieving the debris through 1/8-inch mesh screen. Then place the capsules in other cages to start new cultures. Do not remove the hatched egg capsules from the starting cages for 2 months, as they afford a hiding place as well as the first food for the young nymphs. When the nymphs are 2 months old, transfer them from the starting cages to larger cages (fig. 3). After the adults begin to appear, remove them from the nymphal colonies at biweekly intervals, place them in cages, and hold them for future use. This procedure insures cages of adults of approximately the same age. Insects of known and uniform age are important for experimental purposes.

Approximately 600 adult cockroaches are considered maximum for one cage. A simple formula for estimating the optimum population for any cage is

$$\frac{A + a}{2} = P$$

where A is area in square inches of cage available to insects, a is the square inches of added surface (e. g., pint cartons), and P is the number of roaches. Two square inches is desirable for each adult American



cockroach. A cage 14 by 18 by 7 inches containing 11 round pint cartons will accommodate about 600 adult cockroaches.

Food. --The roaches are fed a mixed diet of two pellet-form foods, a commercial dog ration high in animal protein and a laboratory ration high in vegetable protein. Commercially prepared foods intended for guinea pigs or rabbits were found not suitable for the American cockroach.

Biology. --A knowledge of the life history and habits of the cockroach is necessary for a successful rearing program. Each of the four species discussed here has its own behavior pattern.

From 5 to 9 months is the approximate time required for the American cockroach to become an adult, and some adults have lived as long as 2 years. The number of instars through which this roach may pass during its development varies. Gould and Deay (8, 9) found 13 instars, whereas Griffiths and Tauber (10) and Gier (6) found 11. From this and additional information obtained by the authors it appears that the number of instars can range from 5 to 13. The food and water supply, humidity, temperature, and sex of the roach affect the rate of development and number of instars. Gould and Deay (7) studied the effect of temperature on the American cockroach and found that 70° F. allowed normal development. The authors found that this cockroach thrives best at 75° and 60 percent relative humidity. Averages for an 8-year period in their rearing cabinet were 78° and 60 percent.

Gould and Deay (8, 9) found that the average number of egg capsules deposited per female was 50, with an average of 13 embryos for each capsule. American roaches deposit their egg capsules and glue them to some object near a food supply (Rau 20, 21). This occurs in captivity, although the authors found that large numbers of capsules are scattered on the bottom of the cages. The male occasionally flies, and in tropical and semitropical regions both sexes fly.

Parasites. --Parasites are trouble makers in laboratory cockroach colonies. A red mite, Pimeliophilus podapolipophagus Tragardh, a true parasite, and a white mite, Caloglyphus sp., which feeds on organic matter, can reduce the vigor of a colony. The authors have seen the red mite wipe out a cageful of the American cockroaches. It is necessary to eradicate these mites by fumigating all food as it comes from the manufacturer with methyl bromide at 3 pounds per 1000 cubic feet for 2 hours. When an infestation occurs in the cages, flowers of sulfur are dusted on all shelves on which cages rest. In case of a heavy infestation, all roaches are transferred to a clean cage. All debris and cartons are removed from the infested container. The cage is washed with hot, soapy water and allowed to dry before being used again.

A hymenopterous parasite, Evania appendigaster L., was taken by the authors from an American cockroach culture. Clausen (3) states that this species is an egg parasite.



## German Cockroach

Rearing Room. --German cockroaches are reared in cages placed on open shelves (fig. 6) in a room 15 feet long, 4 feet wide, and 9 1/2 feet high, with windows along one long wall. The temperature of the room is kept at 80°-85° F., and the relative humidity is maintained at 70-75 percent. Ventilation is provided by a suction fan built into a window 5 feet from the floor and operated intermittently.

Rearing Cages. --This species can be reared in any container that will easily confine them. The authors use battery jars (fig. 7). Similar cages have been used by other workers (1, 2, 5, 11, 22, 23, 24, 25). Melampy and Maynard (14) used glass aquaria (fig. 8) and jars. McCay (12, 13) used half-pint milk bottles. The authors have used 25-pound lard cans. Large metal drums and barrels are also used at some laboratories, but then it is difficult to obtain individuals of known and uniform age for testing.

Water is provided in the same manner as for American roaches.

Rearing Procedure. --To start a culture of German cockroaches it is best to obtain gravid females. Place from 100 to 200 roaches in 4- by 6-inch cylindrical cages of 18-mesh copper wire screening (Heal 11). Then put this cage in a battery jar (fig. 9) or similar container so that it rests on coils of corrugated paper bands 1 to 2 inches wide or on the tops of cartons. When the young hatch, they find their way through the screen cage into the jar and then to the paper coils or cartons. The screen cage can be placed in a new battery jar once a week or oftener if desired. The jars are dated so that the age of the cultures will be known. A cage will support twice as large a population of German roaches as of American roaches.

When most of the roaches in any jar have become adults, empty them into a basin that has been rimmed with white oil. Individual roaches for testing may be captured by placing a small vial over them. Put the unused adults and nymphs back into the brood chamber to develop and carry on the culture.

Anesthetics such as chloroform or carbon dioxide, or short exposure to low temperature, are used in some laboratories to facilitate the handling of roaches. However, Olson et al. (16) pointed out the possibilities of after effects. The writers prefer to handle the insects as described above.

Food. --In all probability the German roach feeds on organic material in nature; however, feeding this species in captivity presents an important problem. The type of diet and amount given affects its development and growth. The authors use small cube-type dog biscuits. Commercially



prepared food for guinea pigs or rabbits is not suitable. Many diets have been suggested (12, 13, 16). Some workers make up their own roach food by mixing bran, powdered milk, and dried brewers' yeast.

Biology. --Environmental requirements and biological behavior of the German roach are different from those of the other species mentioned in this paper. A temperature of 80°-85° F. and a relative humidity of 70 percent are best for the development of the German roach. The female carries her egg capsule, partly protruding from her body, for 20 to 28 days (17, 21), or until the young hatch. Woodruff (26) reports that 2 weeks are required for development of embryos. In rearing experiments conducted by the authors a complete life cycle took approximately 80 days. There are six or seven instars (22, 26). Any broken or torn appendages are regenerated at the time of molting (Woodruff 27). This species rarely flies, but when it does, its flight is of the gliding type.

Parasites. --White mites of the genus Caloglyphus have occasionally caused difficulty with cultures of German roaches. Control procedures are discussed on page 3.

### Other Species

Brown-banded roach. --This roach has been reared under the conditions described for the German roach. The female deposits and glues the egg capsules in the same general manner as the American roach. The authors have reared two generations of this species in one year. It has thrived on the laboratory type of dog food. This species is very active.

Oriental cockroach. --The temperature and humidity requirements are the same as for the German roach. It deposits its egg capsules and can be reared in the same way as the American roach, but it has a longer life cycle (Quadri 18). The large size of laboratory dog food is fed this species. Starchy foods can also be fed to this roach (15, 19). The male is winged but the female is wingless. It is not so active as the other species.



# Life-History Data on Four Species of Cockroaches

Species	Maximum egg capsules per female	Eggs in each capsule	Period between extrusion and hatching	Nymphal molts	Nymphal period to last molt	Maximum adult life	Minimum life cycle
	<u>Number</u>	<u>Number</u>	<u>Days</u>	<u>Number</u>	<u>Days</u>	<u>Days</u>	<u>Days</u>
American cockroach	58	16	42-63	5-13	98-200	730	150
German cockroach	5	40	20-28	6-8	50-90	232	80
Brown-banded roach	20	17	42-74	-	125-174	206	177
Oriental cockroach	50	8	45	8-12	220	730	275

The data in this table have been compiled from the literature to show general trends. The wide ranges in certain data are no doubt due to differences in the food and water or in the temperature and relative humidity used by different workers.

The minimum life cycle includes the 10 days required for a new adult to extrude the first egg capsule (4, 18).



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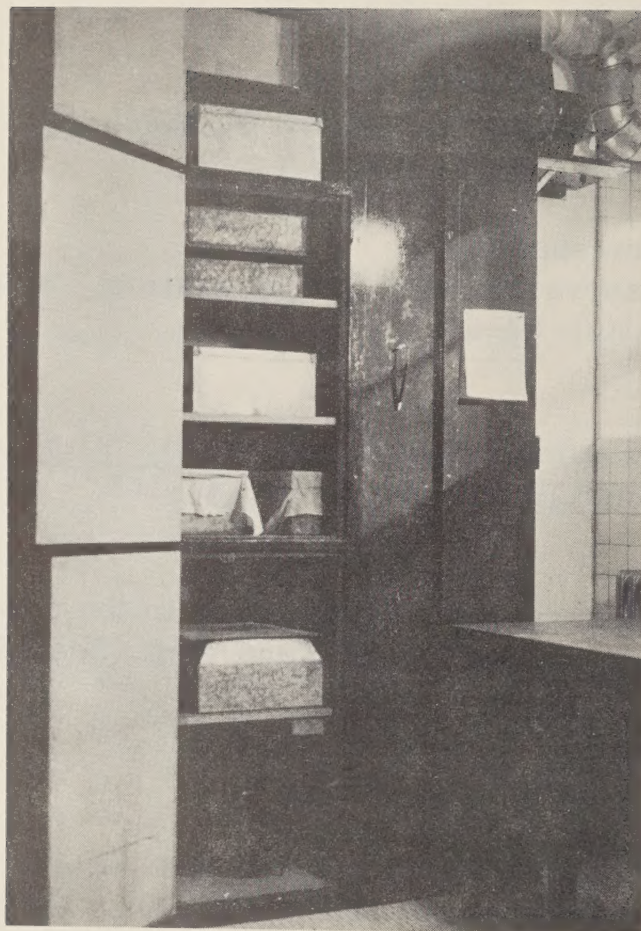


Figure 1.--Rearing cabinet for American cockroaches.



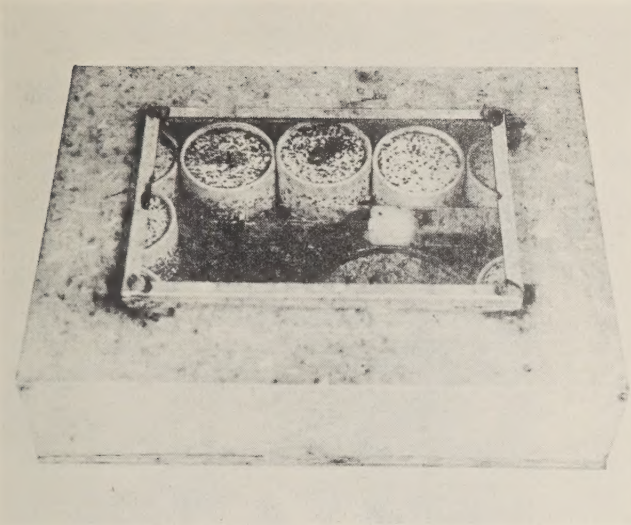


Figure 2. --Hatching cage for American cockroaches.

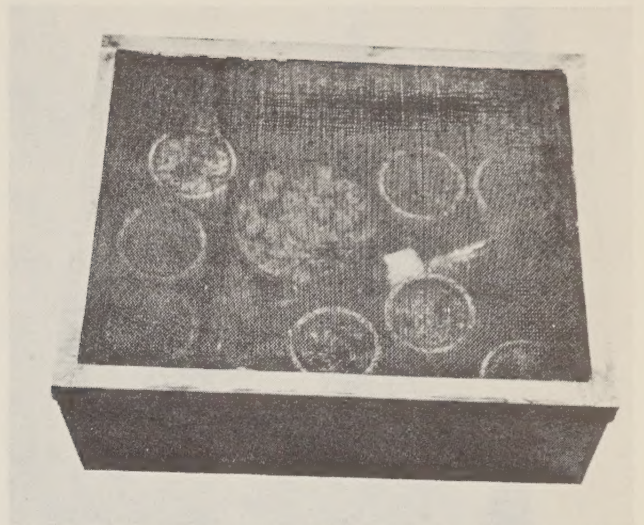


Figure 3. --Rearing cage for nymphs and adults of the American cockroach.

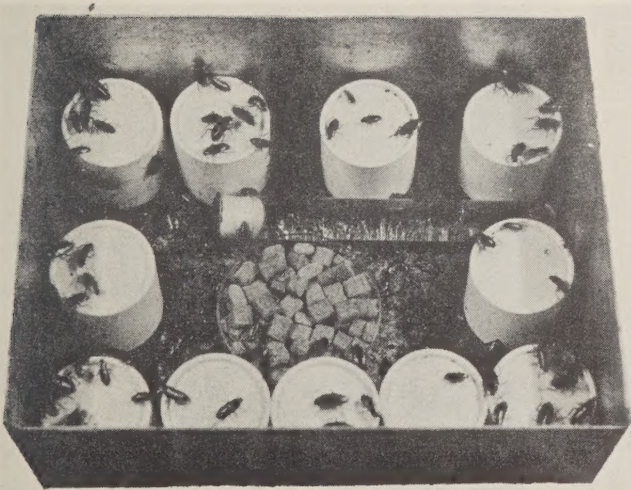


Figure 4. --Cage without top showing American cockroaches.

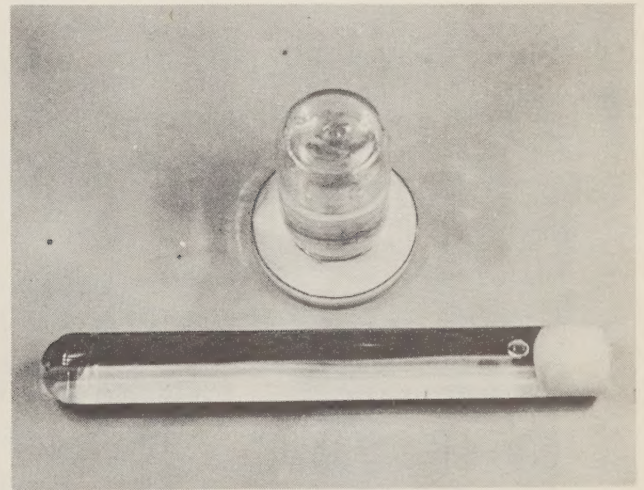


Figure 5. --Two types of watering fountains for cockroaches.





Figure 6. --Rearing room for German cockroaches.

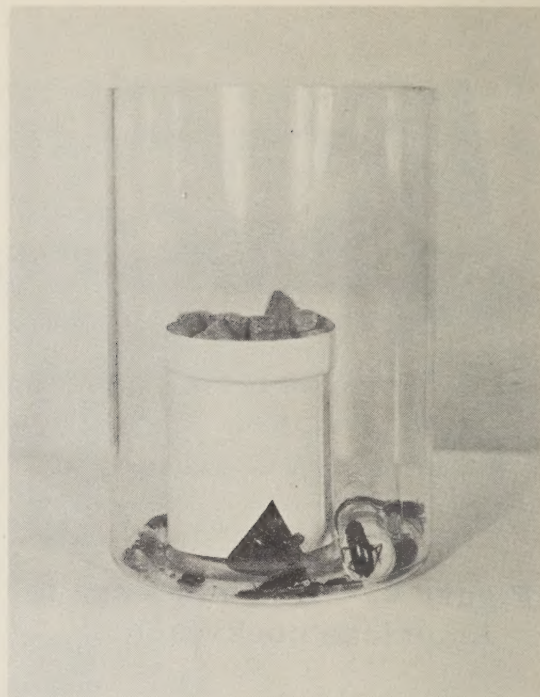


Figure 7. --Battery jar cage for rearing cockroaches.

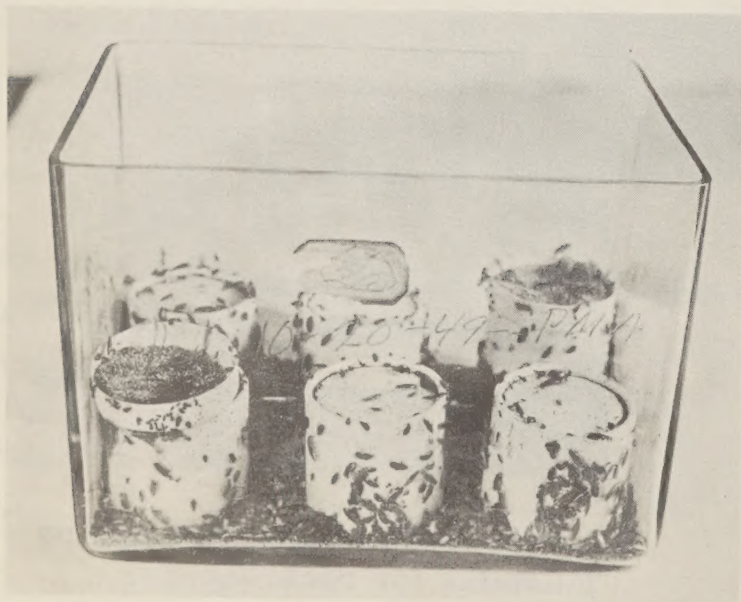


Figure 8. --Glass aquaria for rearing German cockroaches.

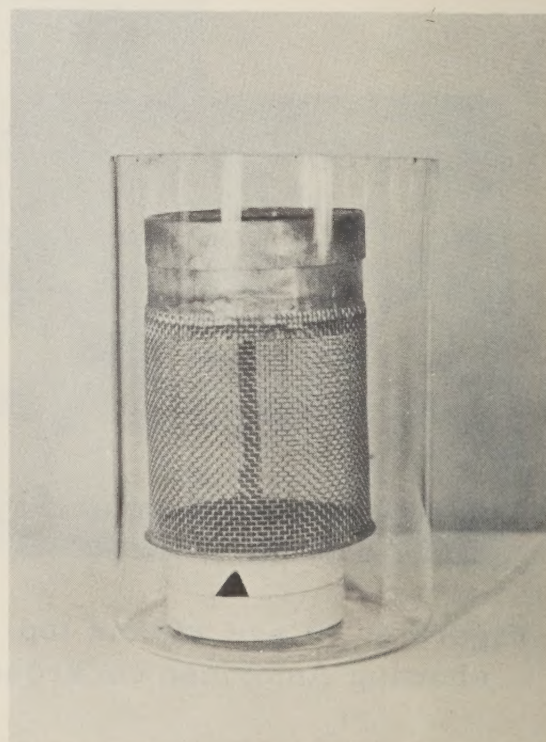


Figure 9. --Battery jar containing wire cage for separating early nymphal stages of the German cockroach.